



Designing a Large Scale Ethology System with Computer Vision

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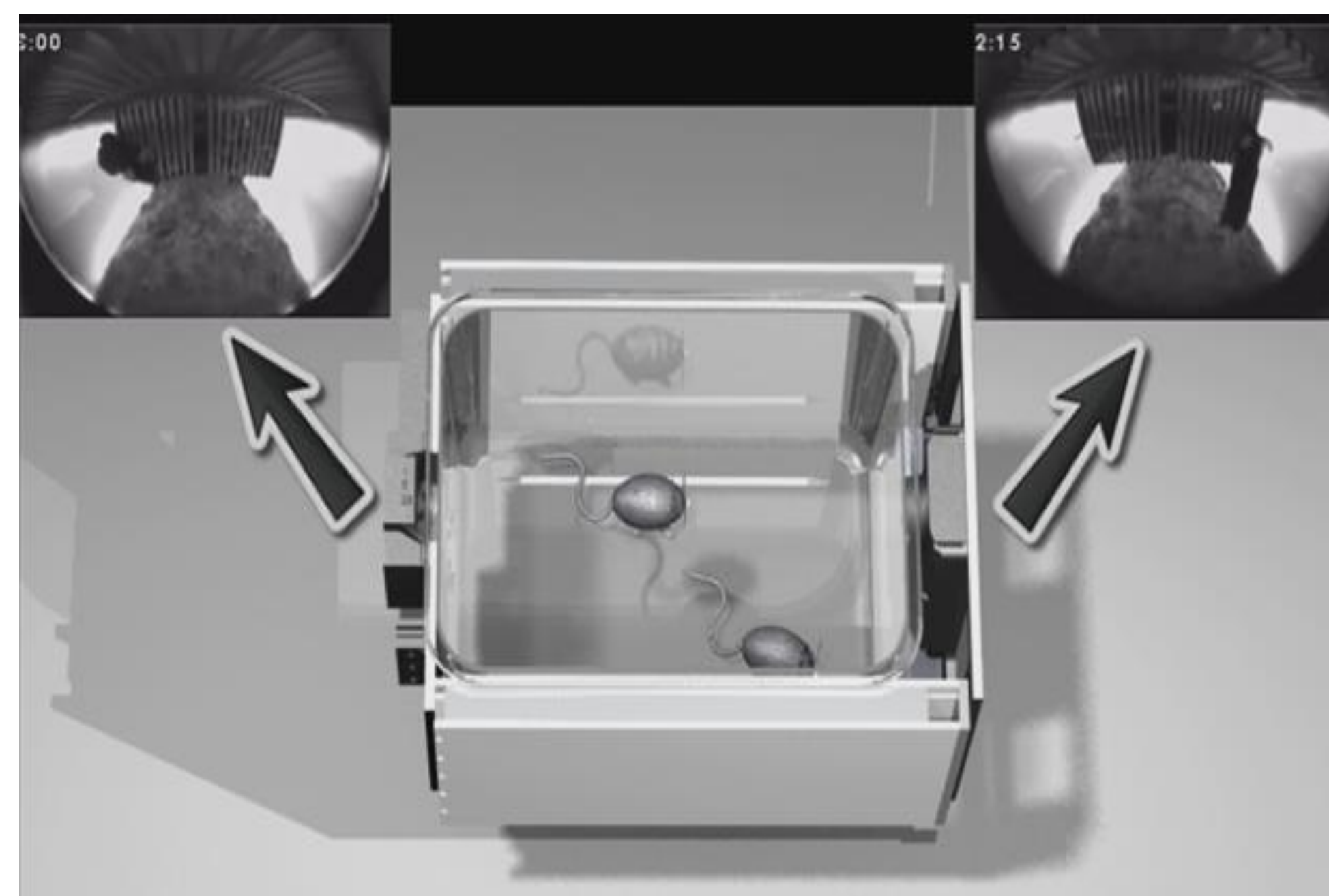
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Background and Introduction

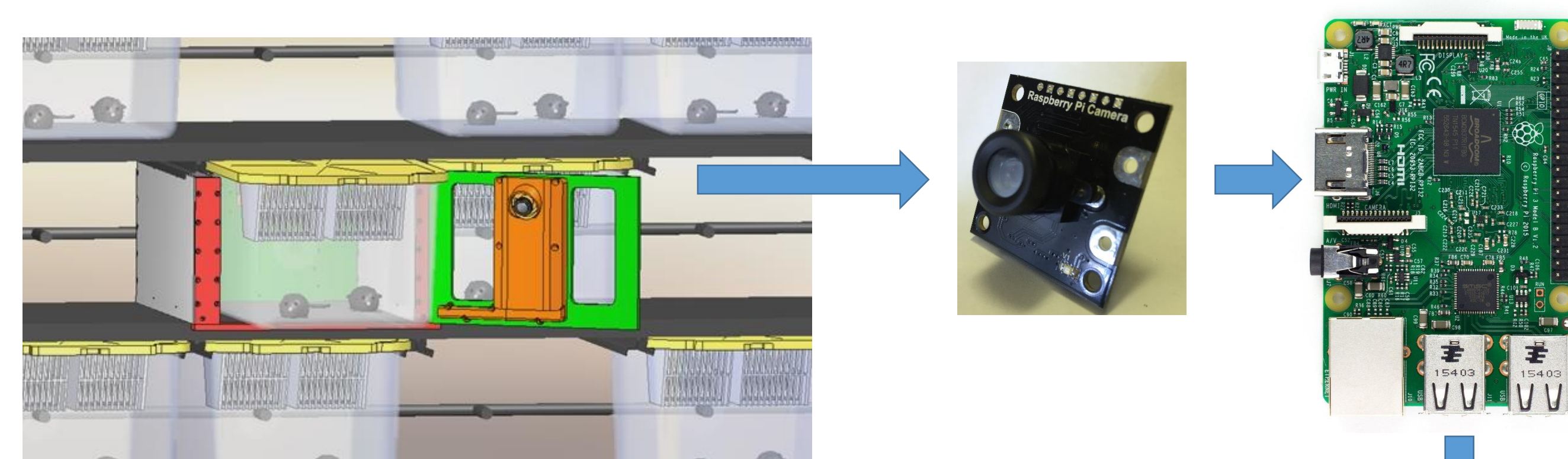
The System for Continuous Observation of Rodents in Home-Cage Environment (SCORHE) is an ongoing effort including many collaborators at NIH across institutes. The SCORHE project aims to develop an automatic behavioral detection system which provides continuous video-based monitoring for animal facilities without home-cage modification. This low-cost system provides accurate data of rodent activity and seeks to eliminate issues common to other mouse-monitoring methods such as acclimation periods and circadian rhythm disruption. Due to the ongoing nature of this project, the work completed this summer focused on improving the current system. The developments made can be categorized into the following groups: mechanical prototyping, system infrastructure, software development, and hardware design.



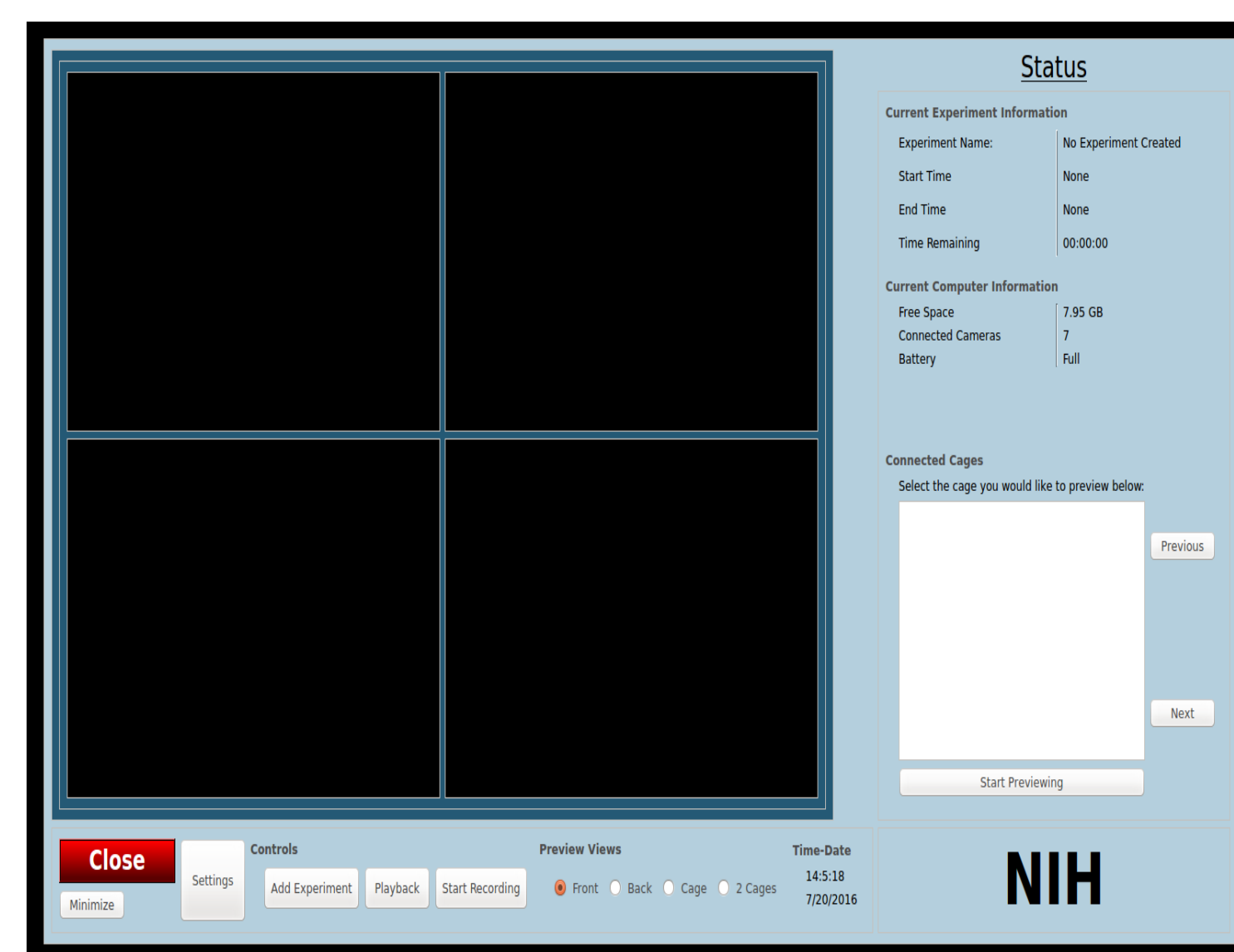
System Infrastructure

Basic Structure

An existing base network was in place, which allows a variable number of clients to connect to a main server, record video, and send recorded video to the server. Each Raspberry Pi is responsible for one camera, and is therefore treated as one client on the network. The diagram below highlights the video acquisition/previewing process.



1. The cages inside the rack house one to two front and rear facing Raspberry Pi controlled cameras.
2. Each Raspberry Pi is connected to a local network which can send commands.
3. The Raspberry pi sends the requested video data from the camera to the server's interface.



Improvements

- Achieved live streaming and recording of video by splitting the Raspberry Pi camera output into two data pipes. One output was sent across the network into a file for the recording, and the other was live streamed to a local server.
- Live previewing using a basic TCP (Transmission Control Protocol) introduced a 7-15 second delay. This delay was eliminated by switching to a RTP (Real Time Protocol) which allowed for live HD recording and previewing with no lag.

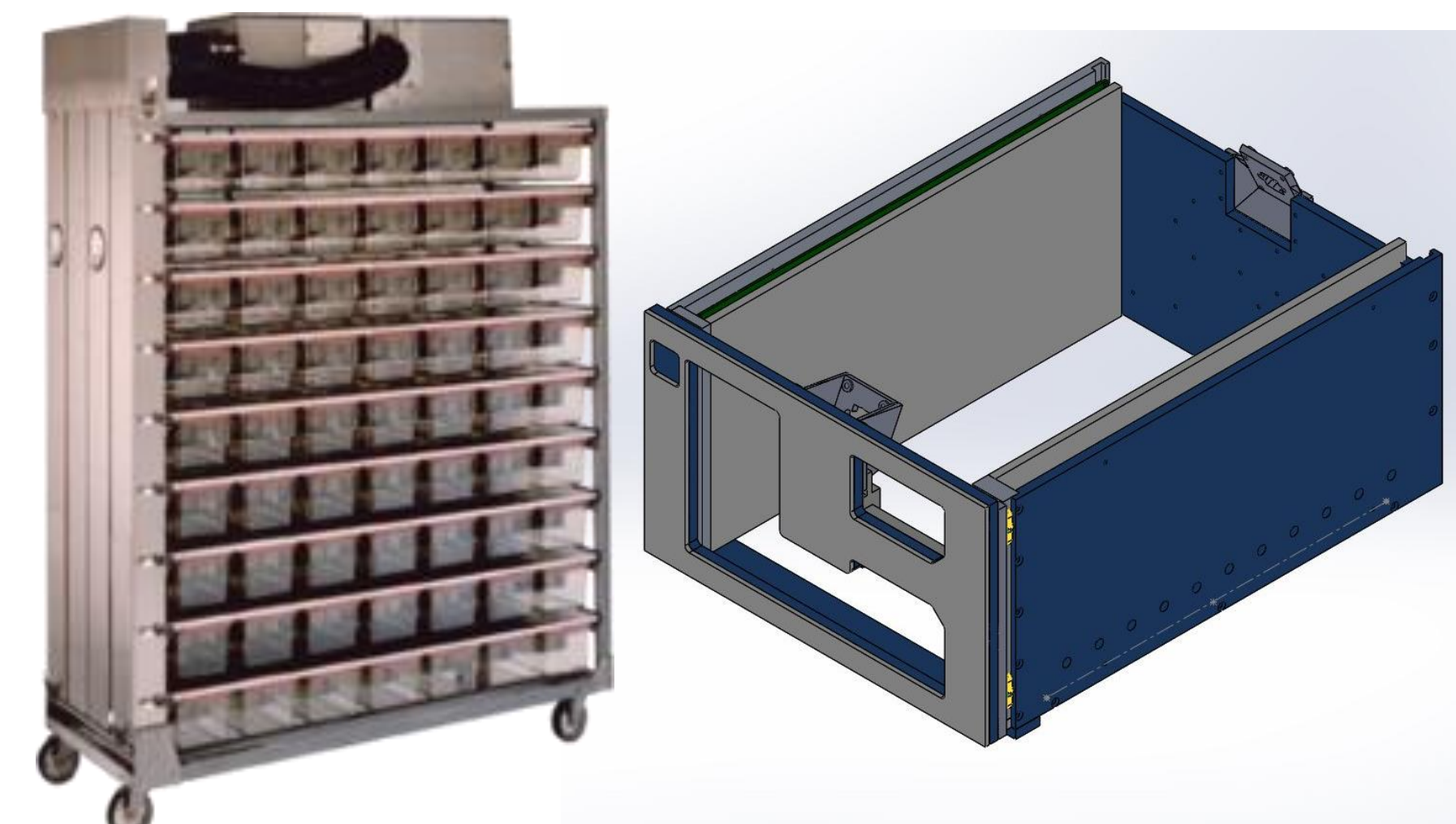
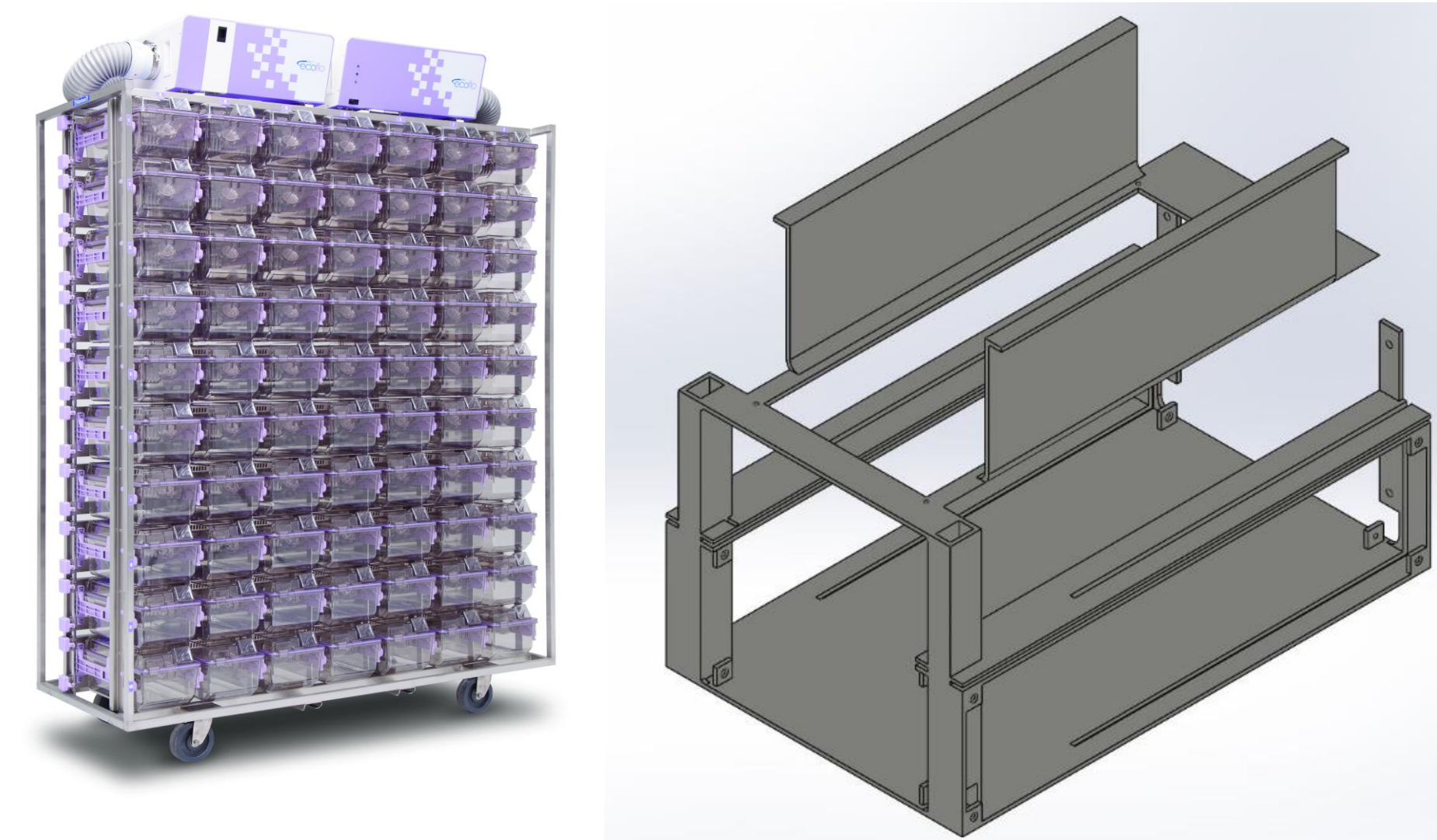
Mechanical Prototyping

The physical design of the new SCORHE system has been developed to allow 24-hour surveillance of cages in Allentown, Incorporated “NexGen” housing racks. This version of SCORHE is more energy efficient compared to previous designs due to it requiring less near-infrared LEDs to illuminate the cage during dark hours. The open frame design also lets the cage be lit by room lights when it is intended. By utilizing dead space within the racks, we are able to use less LEDs for nighttime illumination; making this system more energy efficient compared to older versions. Once the system is installed, the user does not have to remove it in order to remove any cages.

Allentown Racks

Improvements in new design:

- Double the space between LEDs and diffuser
 - Requires less LEDs → less power → less heat
 - Infrared can be diffused more uniformly
- Open design allows “daylight” into cage
- Easy slide-in/slide-out handling of cages
 - “Set it and forget it”
- Aerial surveillance of cages



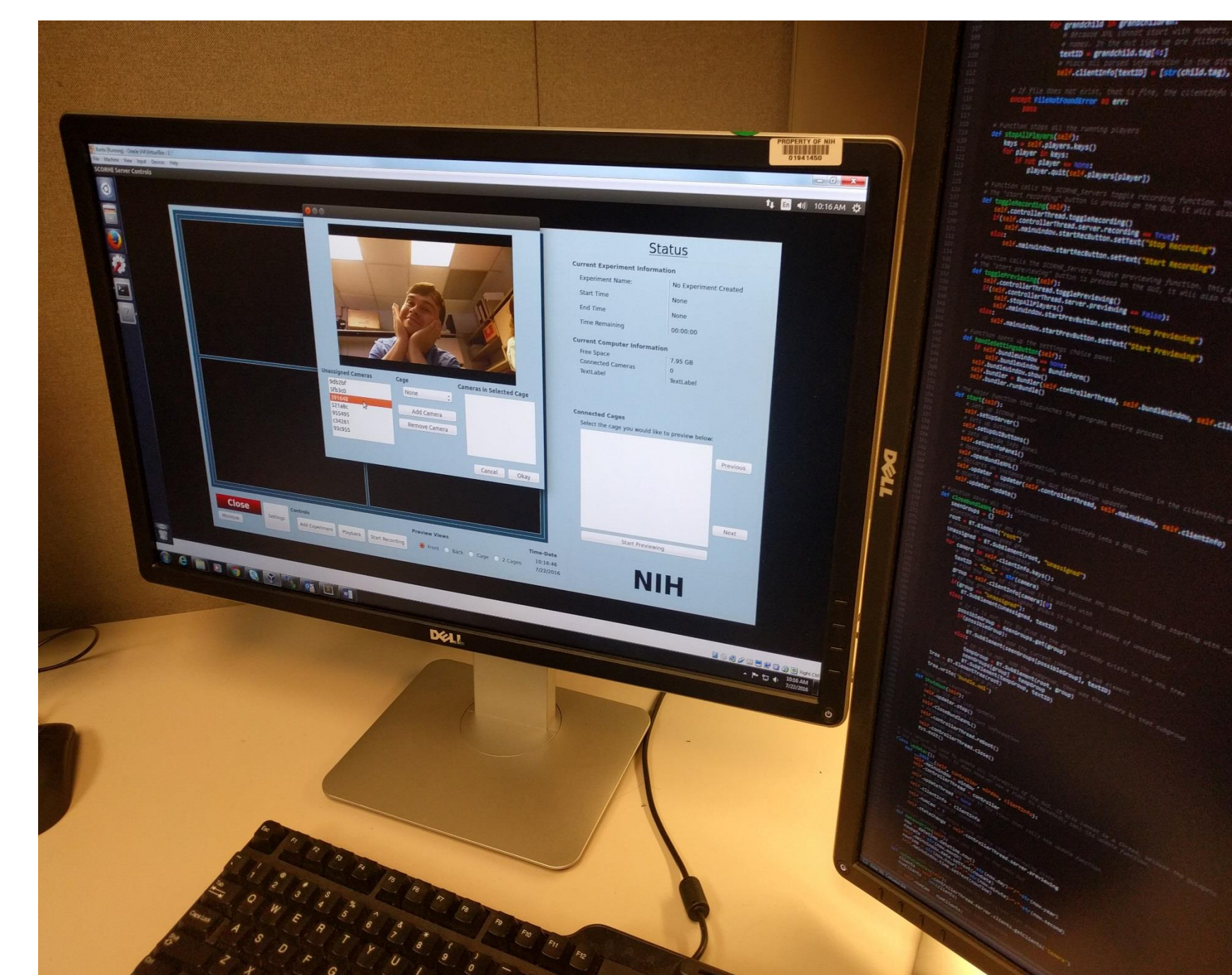
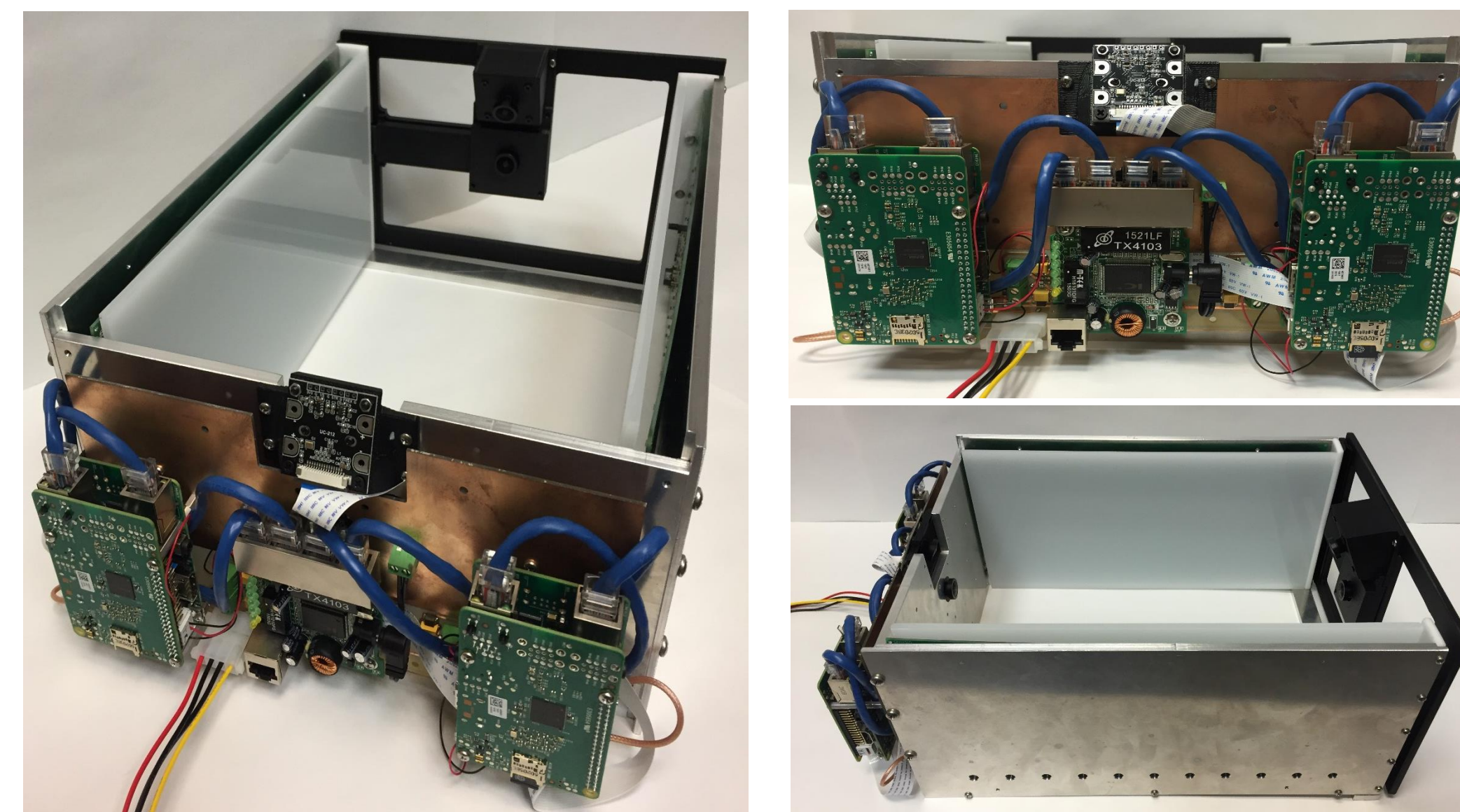
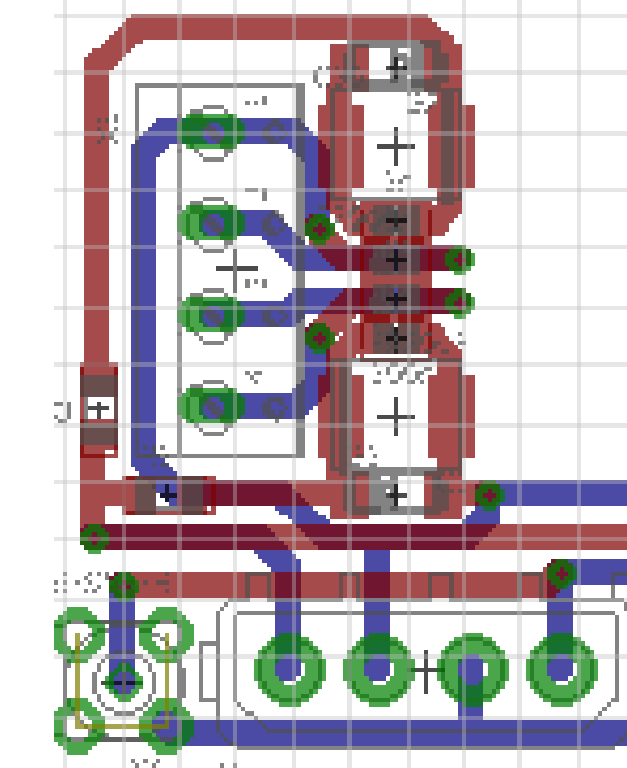
Thoren Racks

Improvements in new design:

- Designed two new 3D printed camera holders
- Changed hinge for better accuracy
- Increased front plate cutout area
 - Less disruption to circadian rhythm
- Created slotted design → easier to assemble
- Integrated hardware PCB design into SolidWorks assembly

Hardware Design

Designed print circuit board using Eagle. This circuit board provides power to the four raspberry pi's and to the Ethernet hub. This design reduced the number of cables from five to two.



Score with SCORHE!!

Want to learn more?

<https://scorhe.nih.gov/>

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Software Development

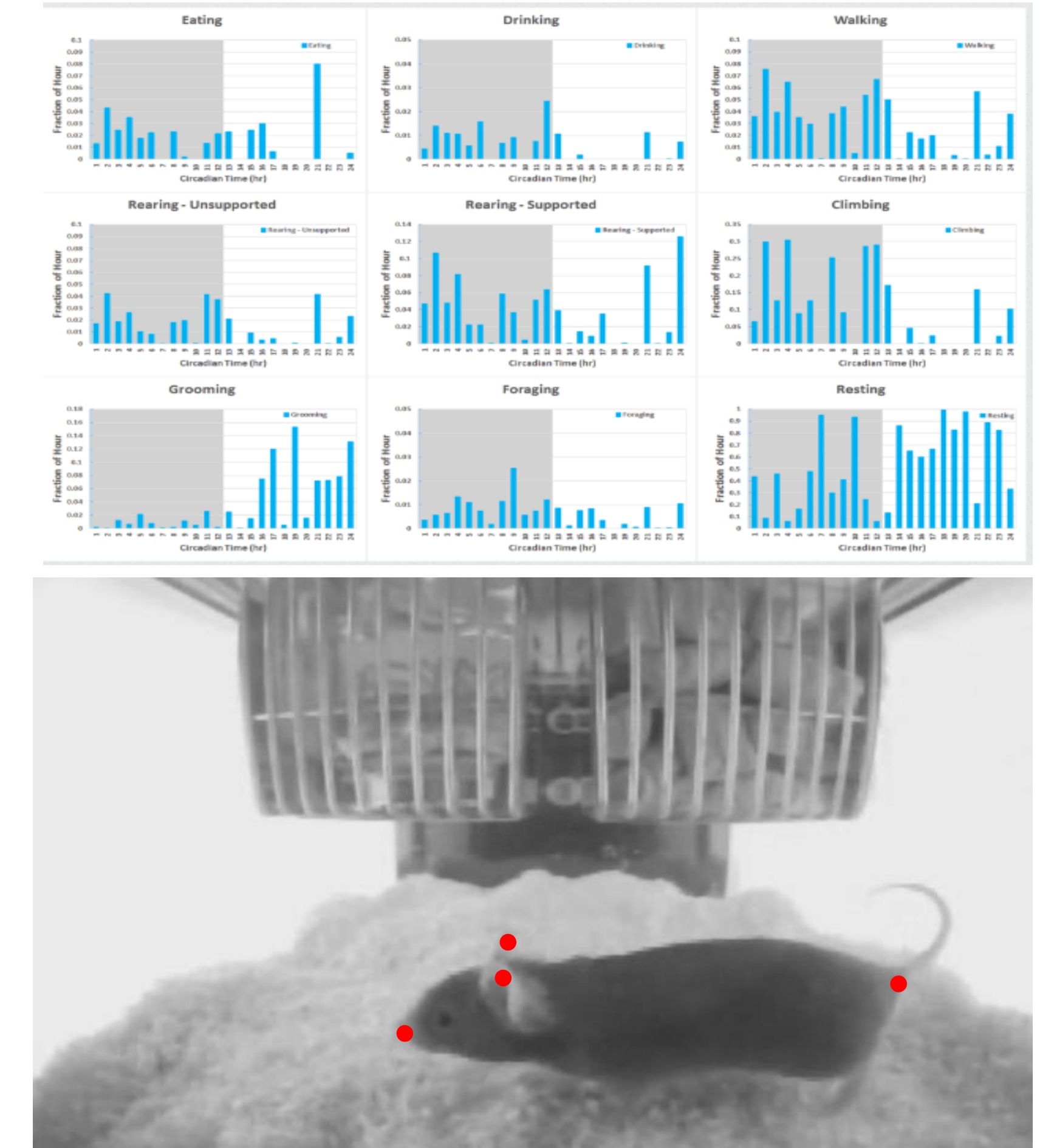
The software development pertains to obtaining user and budget friendly software to accomplish video splicing as well as frame-by-frame annotation of spliced video clips. These tasks have the following requirements:

Video splicing

- Given a time frame, load the appropriate video footage for each camera
- Let the user preview the video, and provide time-stamps for the start point and end point of the video to be spliced
- Splice the video, start and stopping at the designated time points

Frame Annotation

- User to marks information about each frame of spliced video
- Mark current behavior
- Select where head and tail are positioned



Alternatives Resources

Due to prohibitive costs associated with the annotator using MATLAB in a crowd sourced setting, the annotator was reevaluated. Although possible to build a new annotation system, it was resource efficient to find a free, already created, crowd-sourced frame annotator program.

After some searching, we chose to use VATIC (Video Annotation Tool from Irvine, California), which also has the ability to “fill-in” the gaps between annotations. Given an annotation on two non-adjacent frames (barring any erratic mouse movement), the annotator is able to fill in the space between the two frames by generating its own annotations. This increases the potential speed of the annotation process, as it is generally easier to check annotations, than to make them.

Graphic User Interface

- Created user-friendly interface for the server using the python port of the QT framework
- Has grouping functionality so cameras can be linked together for improved organization
- An XML is generated and stores information on camera group assignments where the user can control recording, previewing and other advanced camera settings like ISO

Conclusion

Our work this summer has delivered the project:

- A new mechanical prototype that integrates with vivarium cage systems. The prototype also mounts the Raspberry Pi's needed to record and connect to the network.
- System infrastructure that supports both recording and live-previewing simultaneously. Recordings are high-quality while previewing has minimal delay.
- A graphic user interface prototype for the server, providing a front-end interaction with network. Converted application code to run on Linux.
- A prototyped editor for editing and splicing of video captured by the cameras.
- Using the integrated open source video annotation tool (VATIC) for the system.

References

Salem, G. H., Dennis, J. U., Krynitsky, J., Garmendia-Cedillos, M., Swaroop, K., Malley, J. D., Pajevic, S., Abuhatzira, L., Bustin, M., Gillet, J., Gottesman, M. M., Mitchell, J. B., & Pohida, T. J. (2014). SCORHE: A novel and practical approach to video monitoring of laboratory mice housed in vivarium cage racks. *Behav. Res. Methods*, 47, 1. doi:10.3758/s13428-014-0451-5